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Tall Fescue Response to Nitrogen and Harvest Date for Stockpiled Grazing in the Upper Midwest

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Abstract

Tall fescue (*Festuca arundinacea* Schreb.) is a cool-season grass with physiological and morphological traits suitable for stockpiled grazing. The effect of late summer nitrogen (N) application was measured for yield and quality responses using four N rates (0, 25, 50, and 100 lb/acre) and three autumn harvest dates. Averaged across harvest date, linear increases of dry matter (DM) occurred in 1999 and 2000. In 1999, yield = 1747 + 15 × N rate (R^2 = 0.92, RMSE = 235) and in 2000, yield = 672 + 19 × N rate (R^2 = 0.96, RMSE = 202). Year by harvest date and year by N rate interactions were observed for yield because of above average rainfall in 1999 and below average rainfall in 2000. Forage crude protein (CP) and in vitro dry matter digestibility (IVDMD) increased as N rate increased, while neutral detergent fiber (NDF) decreased. Year by harvest date interactions were observed for CP, NDF, and IVDMD, and year by N rate interactions were observed for CP and NDF. Late summer N application increased DM yield and CP of the first cutting the following spring. Forage producers who apply late-season N can increase the quantity and quality of tall fescue forage available for autumn grazing. However, yield and quality losses can occur if harvest is delayed beyond October.

Introduction

Late summer growth of tall fescue is often allowed to accumulate for autumn and early-winter grazing in the Midwest. Application of fertilizer N increases yield and may improve forage quality of stockpiled grasses, but these responses vary dramatically depending on weather conditions prior to and during the stockpiling period. Gerrish et al. (5) in Missouri found that N application prior to the stockpiling period of 40, 80, and 120 lb/acre increased tall fescue yield by 22, 30, and 35% more than the 0 N treatment. These results were averaged across sward state, timing of N fertilization, and harvest date. Multiple interactions were observed in their study because of weed pressure in certain years and varying precipitation. Collins and Balasko (2) reported that N rates up to 154 lb/acre increased tall fescue DM yield under West Virginia conditions when stockpiling was initiated in mid-June. Moyer et al. (7) in Kansas reported a relationship between DM yield and N rate with an intercept of 2738 lb DM per acre and 13 lb DM per acre increase for each pound of N applied using two years of data.

Because tall fescue maintains growth at lower temperatures than most other cool-season grasses, it is an excellent candidate for deferred grazing. The short day lengths and cool temperatures of late summer and early autumn also cause tall fescue to store free sugars throughout the plant thus maintaining or even increasing the quality of available forage. In addition, the cuticle of tall fescue protects leaves and stems from frost damage and deterioration allowing it to maintain growth and quality for longer periods of time than most other cool-season grasses. Fribourg and Bell (4) in Tennessee reported that CP concentrations decreased 25 to 40% from the start of stockpiling in late summer to concentrations of 2 to 9% in winter. They also reported that concentrations of

NDF did not vary with the duration of stockpiling. Collins and Balasko (3) reported that IVDMD decreased 13% from mid-December to mid-February in West Virginia.

Tall fescue also maintains its upright stature throughout autumn, even with snow cover, which often lodges other cool-season grasses. Quantifying the response of tall fescue to late-season N application would enable producers to make better management decisions when planning their autumn forage programs. The objectives of this experiment were to determine the N response and optimum harvest dates for yield and quality of stockpiled tall fescue.

Field Experiments with Four N Rates and Three Harvest Dates

The experiment was conducted near Ames, Iowa (42°00'N, 93°50'W) on plots located in an established stand of 'Kentucky 31' tall fescue on Clarion loam soil (fine-loamy, mixed, mesic, typic Hapladoll). The tall fescue had last been cut for hay on 24 June 1999 and 26 June 2000. The experimental design was a randomized complete block in a split-plot arrangement of treatments with four replications. Main plots were nitrogen fertilizer rate applied as ammonium nitrate (NH_4NO_3) with a Gandy spreader (Gandy Company, Owatonna, MN) at the rates of 0, 25, 50 and 100 lb N per acre on 19 August 1999 and 16 August 2000. Different plots were used each year to avoid confounding residual soil N and forage yield. Subplots were different autumn harvest dates. Harvest dates for 1999 were 14 October, 25 October and 15 November with a residual-effect harvest occurring on 19 May 2000. Harvests occurred on 17 October, 30 October and 16 November in 2000 with the spring harvest occurring on 16 May 2001.

Strips measuring 25 ft long were cut with a walk-behind sickle-bar mower with a 3-ft effective cutting width at a 2-inch height. Cut material was collected, weighed for yield, and sampled for dry matter determination and laboratory analyses. Samples were dried in a forced-air dryer at 100°F and ground to pass through a 0.04-inch mesh screen using a UDY cyclone mill (UDY Manufacturing, Fort Collins, CO) prior to laboratory analyses.

The IVDMD procedure followed the NC-64 Marten and Barnes (6) direct acidification system based on the Tilley and Terry (9) in vitro method. Neutral detergent fiber was determined using the ANKOM 200 Fiber Analyzer (ANKOM Technology Corp., Fairport, NY) as described by Vogel et al. (10). Crude protein was determined by obtaining the Kjeldahl N value for each sample and multiplying by 6.25 (1). Tillers were randomly harvested 1 November 2001 to quantify the level of endophyte fungus (*Acremonium coenophialum*) in the tall fescue stand. Tillers were chilled overnight and then processed for use with a Phytoscreen Immunoblot Kit (Cat. No. ENDO7973, Agronostics, Ltd. Co., Watkinsville, GA). Results of the "Phytoscreen Immunoblot Kit" test indicated that 9% of the stand was infected with endophyte. Statistical analyses were conducted using the General Linear Models procedure of SAS (8). Regression models were fitted using the REG procedure of SAS. All tests of significance were made at $P = 0.05$.

Results: Tall Fescue Response to N and Harvest Date

Above average rainfall occurred from April through August of 1999 and resulted in high yields for all treatments (Fig. 1). In 2000, in contrast, below average rainfall occurred from June through October. Nevertheless, N application produced linear yield responses both years (Fig. 2). Year main effect was not significant ($P = 0.143$), but harvest date ($P = 0.000$), year by harvest date ($P = 0.002$), and year by N rate ($P = 0.047$) interactions for yield were observed. The significant interaction of year and harvest date occurred because DM yield in 1999, averaged across N rate, was similar among all three harvests (2604, 2347, and 2307 lb DM per acre), while DM yield decreased 48% from the second to third harvest in 2000 (Fig. 3). Excessive weathering and lodging of the stockpiled forage occurred between the second and third harvests in 2000 because precipitation after frost was higher than during 1999. Killing frosts occurred on 20 and 6 October, in 1999 and 2000, respectively. The year by N rate interaction occurred because DM yield in 2000 only increased by 19% as N rate increased from 0 to 25 lb N per acre compared to 32% in 1999.

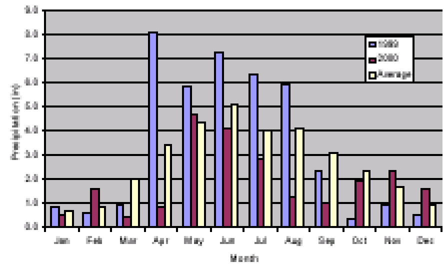

Fig. 1. Annual rainfall by month in 1999 and 2000 compared to the long-term average.

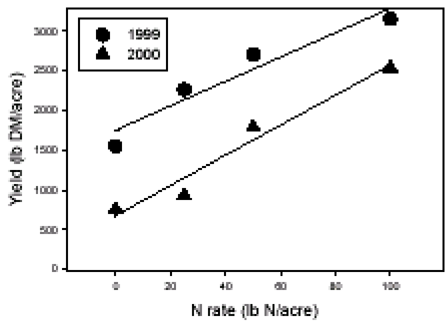

Fig. 2. Dry matter (DM) yield, averaged across fall harvest date, in 1999 and 2000 for different N rates. In 1999 DM yield = 1747 + 15 × N rate, R^2 = 0.92, RMSE = 235. In 2000, DM yield = 672 + 19 × N rate, R^2 = 0.96, RMSE = 202.

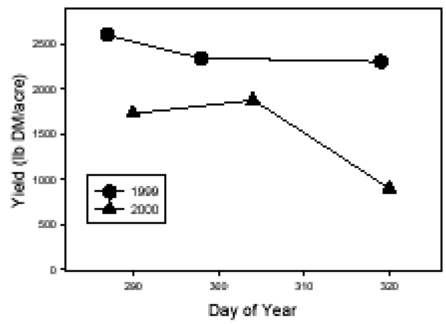

Fig. 3. Dry matter yield, averaged across N rate, for different fall harvest dates in 1999 and 2000.

Crude protein concentration was affected by year, harvest date, and N rate. A year by harvest date interaction was observed because CP decreased from 10.0 to 8.5% in 1999 from Harvest 1 to Harvest 3, averaged across N rate, but was stable in 2000 at 10.5 to 10.9% among harvest dates (Tables 1 and 2). A year by N rate interaction was also observed for CP because the 0 N rate in 2000 had higher CP than in 1999 (8.7 versus 7.5%) and the 100 lb N rate had higher CP in 2000 than in 1999 (13.3 versus 10.9%). Collins and Balasko (3) also reported year by harvest and year by N rate interactions for CP. Differences in rainfall between 1999 and 2000 most likely explain the different CP response that was observed for N rate. Main effects of year and N rate were significant for NDF. A year by harvest date interaction was observed because in 1999, averaged across N rate, NDF was similar at Harvest 1 and 2 (52 and 53%), but in 2000 NDF at Harvest 1 (55%) was lower than at Harvest 2 (57%). A year by N rate interaction was also observed because NDF, averaged across harvest date, was similar in 1999 between the 0 and 25 lb N rate (55 and 54%) and in 2000 between the 25 and 50 lb N rate (55 and 55%). Fewer differences were observed for IVDMD. A year by harvest date interaction was observed because in 1999, averaged across N rate, similar IVDMD was observed at Harvest 1 and 2 (61 and 61%), while Harvest 3 had lower IVDMD (58%). In 2000, no differences were observed among harvest dates 1, 2, or 3, respectively (58, 57, and 58%). Differences between years and among harvest dates for IVDMD were likely related to the duration of time after frost and the extent of weathering that occurred. In 1999, frost occurred on 20 October, 5 days after and 6 days before first and second harvest, while third harvest was 26 days later. In 2000, frost occurred on 6 October, while first, second, and third harvests occurred 11, 24, and 41 days later. Averaged across year and harvest date, IVDMD increased from 56 to 61% as N rate increased from 0 to 100 lb/acre.

Table 1. Crude protein (CP), neutral detergent fiber (NDF), and in vitro dry matter digestibility (IVDMD), in percent, of tall fescue at three fall harvests at four nitrogen (N) rates, near Ames, IA in 1999.

N rate	Harvest 1			Harvest 2			Harvest 3		
	CP	**NDF**	**IVDMD**	**CP**	**NDF**	**IVDMD**	**CP**	**NDF**	**IVDMD**
0	7.9	56	58	7.8	54	59	6.8	57	55
25	9.5	53	60	8.1	54	60	7.5	56	57
50	10.9	52	62	9.7	51	63	9.4	54	60
100	11.7	51	63	10.8	51	63	10.2	52	62
Mean	10.0	53	61	9.1	53	61	8.5	55	59
SE†	0.4	1	1	0.4	1	1	0.4	1	1

† Standard error of the mean.

Table 2. Crude protein (CP), neutral detergent fiber (NDF), and in vitro dry matter digestibility (IVDMD), in percent, of tall fescue at three fall harvests at four nitrogen (N) rates, near Ames, IA in 2000.

N rate	Harvest 1			Harvest 2			Harvest 3		
	CP	**NDF**	**IVDMD**	**CP**	**NDF**	**IVDMD**	**CP**	**NDF**	**IVDMD**
0	8.8	57	54	8.6	57	55	8.7	57	56
25	10.1	54	59	9.3	57	56	10.0	55	57
50	11.1	55	59	10.8	57	58	10.9	55	59
100	13.7	53	60	13.1	56	58	12.9	54	60
Mean	10.9	55	58	10.5	57	57	10.6	55	58
SE†	0.4	1	1	0.4	1	1	0.4	1	1

† Standard error of the mean.

Nitrogen application increased DM yield of the first cutting in the spring after N application. Averaged across year (P = 0.118), DM yield increased from 682 lb DM per acre at the 0 N rate to 853, 1096, and 1328 lb DM per acre at the 25, 50, and 100 lb N rate, respectively. These results are consistent with Collins and Balasko (2), who also reported that spring forage yields after late summer and autumn N application were higher as N rate increased. They applied as much as 250 lb N per acre and observed a residual curvilinear response to N rate. It is important to note, however, that because this was a clipping study, autumn soil conditions affect the impact grazing cattle have on the forage stand, which affects dry matter production the following spring. Spring forage IVDMD was unaffected by year or N rate. Similarly, N rate did not affect NDF, but it was higher in 1999 compared to 2000 (58 versus 54%). The residual affect of the previous N management was most obvious for forage CP. Crude protein levels were higher in 2000 compared to 1999. A year by N rate interaction was observed because CP at the 0, 25, and 50 lb N rate were similar in 1999 (9.4, 9.4, and 10.0%) and CP for the 50 and 100 lb N rate were similar (10.0 and 10.5%), but in 2000 the 25 and 50 (12.0 and 13.4%) and 50 and 100 lb N rate were different (13.4 and 15.3%). The 8 inches of rainfall in April of 1999 probably leached residual nitrogen from the rootzone and most likely explains the lower CP concentrations in the spring of 1999 compared to 2000.

Summary

Averaged across harvest date, linear increases of DM occurred in 1999 and 2000 in response to N application. Year by harvest date and year by N rate interactions were observed for yield because of above average rainfall in 1999 and below average rainfall in 2000. Yield losses for the third harvest in 2000 were high because of excessive weathering and lodging. Forage CP and IVDMD increased as N rate increased, while NDF decreased. Year by harvest date interactions were observed for all quality measures, but only year by N rate interactions were observed for CP and NDF. Late summer N application increased DM yield and CP of the first cutting the following spring. Forage producers who apply up to 100 lb per acre late-summer N can increase the quantity and quality of tall fescue forage available for autumn grazing. However, yield and quality losses can occur if harvest is delayed beyond October.

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